Total No. of Printed Pages—11

HS/XII/Sc/Ph/23

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PHYSICS

(Theory)

Full Marks : 70

Time : 3 hours

The figures in the margin indicate full marks for the questions

General Instructions :

(i) There are **31** questions in all. All questions are compulsory.

(ii) This Question Paper has four Sections : Section—A (Part—I and Part—II), Section—B, Section—C and Section—D.

(iii) Section—A (Part—I) contains five multiple choice questions of *1* mark each and Section—A (Part—II) contains five questions of *1* mark each. Section—B contains nine questions of *2* marks each, Section—C contains nine questions of *3* marks each and Section—D contains three questions of *5* marks each.

(iv) There is no overall choice. However, internal choices have been provided in three questions of *1* mark, four questions of *2* marks, five questions of *3* marks and all the three questions of *5* marks weightage. You have to attempt only one of the choices in such questions.

(v) You may use the following values of physical constants, wherever necessary :

$c = 3 \times 10^8$ m/s

$h = 6 \cdot 63 \times 10^{-34}$ J s

$e = 1 \cdot 6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8 \cdot 854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$m_e = 9 \cdot 1 \times 10^{-31}$ kg

Mass of neutron $= 1 \cdot 675 \times 10^{-27}$ kg

Mass of proton $= 1 \cdot 673 \times 10^{-27}$ kg

Avogadro's number $= 6 \cdot 023 \times 10^{23}$ per gram mole

Boltzmann constant $= 1 \cdot 38 \times 10^{-23}$ J K^{-1}

SECTION—A

PART—I

(Multiple choice type questions)

Choose and write the correct option for the following : 1×5=5

1. A conductor of resistance R is stretched to two times its initial length, keeping the volume constant. What will be its new resistance?

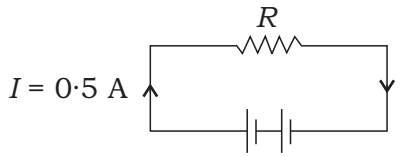
(a) $2R$

(b) $R/2$

(c) $4R$

(d) R 1

2.



In the circuit shown above, each cell has an e.m.f. 2 V and an internal resistance of 1 Ω. The current flowing through the circuit is 0·5 A. The resistance of the resistor R is

(a) 6 Ω

(b) 4 Ω

(c) 8 Ω

(d) 2 Ω 1

3. If the number of turns, area and current through a coil are n, A and I respectively, then its magnetic moment is

(a) n^2IA

(b) nIA^2

(c) nIA

(d) nI^2A 1

4. The transition of electron from $n = 4, 5, 6, \ldots$ to $n = 3$ corresponds to

(a) Lyman series

(b) Balmer series

(c) Paschen series

(d) Brackett series 1

5. Monochromatic light of wavelength 4500 Å is incident on a clean metal surface of work function 2·3 eV. The maximum kinetic energy of ejected photoelectrons is 0·5 eV, then the energy of the incident photon is

(a) 1·8 eV

(b) 2·8 eV

(c) 11·5 eV

(d) 12·8 eV 1

PART—II

(Very short answer type questions)

Answer each of the following questions in *1* sentence/step : 1×5=5

6. *Either*

Power of 60 W is being supplied to an electrical appliance, under a potential difference of 240 V. What is the current flowing through the appliance? 1

Or

A heating element connected to a 12 V battery draws a current of 5 A. How much electric power is supplied? 1

7. Define 'quality factor' of resonance in *L-C-R* series circuit. Write down its mathematical relation. 1

8. *Either*

Calculate the magnifying power of an astronomical telescope for normal adjustment if the focal lengths of its objective and eyepiece are 50 cm and 10 cm respectively. 1

Or

The phase difference between two waves meeting at a point is $\frac{3\pi}{2}$. What is the corresponding path difference? 1

9. *Either*

Define the term 'stopping potential' in relation to photoelectric effect. 1

Or

Why does photoelectric emission not take place if the frequency of incident radiation is less than the threshold value? 1

10. What is nuclear fission? Write a nuclear fission reaction. 1

SECTION—B

(Short answer type–I questions)

Answer each of the following questions within *20* to *30* words, wherever applicable : 2×9=18

11. *Either*

A cell of e.m.f. 1·1 V and an internal resistance of 0·5 Ω is connected to a wire of resistance 0·5 Ω. Another cell of the same e.m.f. is connected in series but the current in the wire remains the same. Find the internal resistance of the second cell. 2

Or

Two capacitors charged with $4{\cdot}8\times10^{-8}$ C each are connected in parallel to each other. If the potential difference of one of the capacitors is 12 V, calculate the total energy stored in both the capacitors. 2

12. Write the working principle of a transformer. How is it useful for long distance transmission? 1+1=2

13. *Either*

An alternating source of e.m.f. $E = E_0 \sin \omega t$ is applied to a circuit containing a capacitor only. Show that the current leads the e.m.f. by $\frac{\pi}{2}$ radian. 2

Or

State Lenz's law and explain that it is in accordance with the law of conservation of energy. 1+1=2

14. A capacitor has been charged by a d.c. source. What are the magnitudes of conduction and displacement currents, when it is fully charged? 1+1=2

15. The wavelength of an electromagnetic wave is 3×10^{-9} m. Which region of the electromagnetic spectrum does it belong to? Calculate its frequency. 1+1=2

16. *Either*

Show that the effective power of two thin lenses in contact is the sum of the power of each lens. 2

Or

Derive the relationship between critical angle and refractive index. 2

17. *Either*

(a) In the hypothetical fission reaction

$$_{92}X^{236} \rightarrow {}_{a}Y^{144} + {}_{36}Z^{b} + 3\ {}_{0}n^{1}$$

what are the values of a and b ?

(b) Write down the relation between 'mass defect' and 'binding energy'. 1+1=2

Or

The binding energies of $_{8}O^{16}$ and $_{17}Cl^{35}$ are 127·35 MeV and 289·3 MeV respectively. Calculate the binding energy per nucleon of $_{8}O^{16}$ and $_{17}Cl^{35}$, and state which of the two nuclei is more stable. 1+1=2

18. What is meant by the term 'doping'? Mention the various methods of doping. 1+1=2

19. With the help of a circuit diagram, explain the use of junction diode as a half-wave rectifier. 1+1=2

SECTION—C

(Short answer type–II questions)

Answer each of the following questions within *30* to *40* words, wherever applicable : 3×9=27

20. *Either*

Using Gauss's theorem, derive an expression for an electric field at a point near a uniformly charged infinite plane sheet. 3

Or

What is a parallel-plate capacitor? Derive an expression for the capacitance of a parallel-plate capacitor. 1+2=3

21. *Either*

Deduce a relation between the drift velocity and current flowing through a conductor. Using the magnitude of drift velocity in the relation, show that

$$R = \frac{ml}{nAe^2\tau}$$

where the symbols have their usual meanings. 1+2=3

Or

Apply Kirchhoff's laws to obtain the condition of balance of a Wheatstone bridge. 3

22. State Biot-Savart's law. Using this law, obtain an expression for the magnetic field at the centre of a circular loop of radius r carrying a steady current I. 1+2=3

23. *Either*

What is a solenoid? Considering an air-cored solenoid of length l, area of cross-section A and having total number of turns N, show that the coefficient of self-inductance L is given by

$$L = \frac{\mu_0 N^2 A}{l}$$ 3

Or

Derive the relation $I_{\text{r.m.s.}} = \frac{I_0}{\sqrt{2}}$, where $I_{\text{r.m.s.}}$ and I_0 are the root-mean-square value and peak value of an alternating current. 3

24. What is an optical fibre? Explain the principle of its working. Mention two of its applications. 1+1+1=3

25. A ray of light suffers minimum deviation while passing through a prism of refractive index 1·5 and refracting angle 60°. Calculate—

(a) the angle of deviation;

(b) the angle of incidence. 2+1=3

26. *Either*

The work function of cesium is 2·14 eV. Find—

(a) the threshold frequency for cesium;

(b) the wavelength of the incident light if the photoelectric current is brought to zero by a stopping potential of 0·60 V. 1+2=3

Or

A particle is moving three times as fast as an electron. The ratio of the de Broglie wavelength of the particle to that of the electron is $1{\cdot}813 \times 10^{-4}$. Calculate the particle's mass and identify the particle. 2+1=3

27. *Either*

Prove that the radius of the n^{th} Bohr orbit of an atom is directly proportional to n^2, where n is the principal quantum number. 3

Or

Calculate the binding energy per nucleon for $_{30}Zn^{64}$ in MeV. (Take 1 a.m.u. = 931 MeV)

Given,

mass of proton = 1·00728 a.m.u.

mass of neutron = 1·00867 a.m.u.

mass of $_{30}Zn^{64}$ = 63·9423 a.m.u. 3

28. *(a)* What are intrinsic semiconductors? Name the types of extrinsic semiconductor obtained when germanium is doped with *(i)* arsenic and *(ii)* gallium.

(b) Draw the *I-V* characteristics of a *p-n* junction diode in forward and reverse bias. (1+1)+1=3

SECTION—D

(Long answer type questions)

Answer each of the following questions within *70* to *80* words, wherever applicable : 5×3=15

29. *Either*

What is meant by diffraction of light? Deduce the condition for the position of secondary minima of diffraction pattern in terms of path difference. Also, find the expression for the width of central maxima. 1+3+1=5

Or

With the help of a neat diagram, explain the working of a compound microscope. Obtain an expression for its magnifying power when the final image is formed at least distance of distinct vision. 2+3=5

30. *Either*

Derive an expression for the electric potential at any point at a distance *r* from the centre of an electric dipole. Hence, find the potential if the point lies on *(i)* axial line and *(ii)* equatorial line. 4+½+½=5

Or

Derive the expression of electric field at any point on the perpendicular bisector of a short electric dipole. Write the expression of the electric field, in its vector form, when the point is very far away from the dipole. 4+1=5

31. *Either*

Describe the principle and working of a moving-coil galvanometer. Show that the deflection produced in the coil is directly proportional to the current flowing through it. 2+3=5

Or

(a) Find an expression for the force per unit length between two parallel wires carrying current in the same direction. Hence, define ampere.

(b) Explain how a galvanometer can be converted to a voltmeter. (2+1)+2=5

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